



Fermi National Accelerator Laboratory

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Guidelines for Structural Bolting in Accordance with the AISC Ninth Edition "Manual of Steel Construction"

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"Manual of Steel Construction"**

by: Jeffrey L. Western

1. INTRODUCTION

This paper specifies the usage of structural bolts in terms of their design, selection and application, in accordance with the the American Institute of Steel Construction (AISC) Ninth Edition. " Manual of Steel Construction ".

2. GENERAL GUIDELINES

2.1 All bolts used shall have identification or grade marks as specified by the American Society for Testing and Materials (ASTM), the Society of Automotive Engineers (SAE), or the International Organization for Standardization (ISO), as identified by Industrial Fasteners Institute (IFI) guidelines. See the attached table "Properties of Steel Fasteners" for common fasteners.

2.2 All structural bolting shall conform to the standard specifications as specified in AISC " Manual of Steel Construction ".

2.3 Bolts not having identification shall not be used, unless material verification has been obtained.

2.4 Preventative steps to alleviate corrosion shall be taken when bolts are exposed to corrosive environments.

2.5 All bolts subjected to a fatigue loading shall be designed for such loads.

2.6 Washers and nuts shall be of the same material as the bolting material, unless compatibility of different materials can be demonstrated.

3. STRUCTURAL BOLTING GUIDELINES

3.1 All structural bolting shall conform to the standard specifications as stated in AISC.

3.1.1 Reference Sections:

- a) AISC Part 4; p. 4-3 thru p. 4-8. Bolts, Threaded Parts and Rivets.
- b) AISC Section J3; p. 5-71 thru p. 5-77.
Specification: Bolts, Threaded Parts and Rivets.
- c) AISC Section C-J3; p. 5-165 thru p. 5-170.
Commentary: Bolts, Threaded Parts and Rivets.
- d) AISC p. 5-263 thru p. 5-307. Specification for Structural Joints Using ASTM A325 or A490 Bolts.

3.2 All bolts that are designated for support application shall follow AISC provisions for allowable, minimum, and maximum stresses.

3.3 All bolts subjected to a fatigue loading shall be in accordance with AISC Appendix K Section K4; p. 5-106 thru p. 5-116.

3.4 The minimum end distance from center of bolt hole shall be in accordance with AISC J3.9; p. 5-75 thru 5-77.

3.5 The maximum edge distance shall not exceed provisions set in AISC Section J3.10; p. 5-77.

3.6 All bolts shall be spaced in accordance with AISC J3.8; p. 5-75.

3.7 The maximum size of fastener holes shall be specified by AISC J3.2; p. 5-71.

3.8 A325 or A490 bolts, that are to be used within a friction or bearing type connection, shall have a minimum pretensioning force of $.7F_u$ applied to them. See AISC Table J3.7; p. 5-77, Section M2.5; p. 5-88 and Section C-M2.5; p. 5-182. AISC provisions for friction shear connections only apply to high strength bolts (A325 and A490).

3.9 Bolts that encounter extraneous loads or stresses such as eccentric shear, prying action, connection bearing stress, or block shear shall be designed under AISC guidelines.

3.10 Bolts that are subjected to **tension** shall follow the following AISC code provisions. See AISC Table 1-B; p. 4-3.

- 3.10.1** $F_t = P / A_g \leq .33F_u$ for allowable tensile stress in threaded fasteners and:
- 3.10.2** $F_t = P / A_g \leq .60F_y$ for the allowable tensile capacity on the gross area of the bolt.
- 3.10.3** Reference Tables / Sections:
 - a) AISC Table 1; p. 5-117. Allowable stress in terms of F_y .
 - b) AISC Table 2; p. 5-118. Allowable stresses as a function of F_u .
 - c) AISC Table J3.2; p. 5-73. Allowable stress on fasteners.
 - d) AISC Table 1-A & 1-B; p. 4-3. Allowable stresses and loads on bolts and threaded fasteners.

3.11 Bolts that are subjected to **shear** with a **bearing-type connection** shall follow AISC guidelines. See AISC Table 1-D; p. 4-5.

- 3.11.1** $F_v = V / A_g \leq .17 F_u$ where bolts create a bearing-type connection and threads are in the shear plane.
- 3.11.2** $F_v = V / A_g \leq .22 F_u$ where bolts create a bearing-type connection and threads are excluded from the shear plane.
- 3.11.3** Reference Table / Sections:
 - a) AISC Table 1-D; p. 4-5. Allowable shear load.
 - b) AISC Table J3.2; p. 5-73. Allowable stress on fasteners.
 - c) AISC Table 2; p. 5-118. Allowable stresses as a function of F_u .

3.12 Bolts that are subjected to **shear** with a **friction-type connection** shall follow AISC "Structural Joints Using ASTM A325 or A490 Bolts" p. 5-263 thru p. 5-307.

- 3.12.1** Reference Tables / Sections:
 - a) AISC Section J3.2; p. 5-73. Allowable stress on fasteners.
 - c) AISC Section M2.5; p. 5-88. High-strength bolted construction assembly.

d) AISC Section C-M2.5; p. 5-182. Commentary:
High-strength bolted construction assembly.

3.13 Bolts that are subjected to **combined tension and shear** shall follow AISC Section J3.5; p. 5-72 thru 5-74. Bolts that are not identified in AISC Table J3.3; p. 5-74 shall adhere to the following:

3.13.1 $F_t \leq .43F_u - 1.8F_v \leq .33F_u$; for a connection where threads are in the shear plane.

3.13.2 $F_t \leq .43F_u - 1.4F_v \leq .33F_u$; for a connection where threads are excluded from the shear plane.

3.14 Nomenclature

T - denotes the tension force (lbs or kips) on the bolt.

V - denotes the shear force (lbs or kips) on the bolt.

A_g - denotes the gross area (in²) of the bolt based on the nominal diameter of the bolt.

F_u - denotes the specified minimum tensile stress (psi or ksi) of the type of steel or fastener being used.

F_y - denotes the specified minimum yield stress (psi or ksi) of the type of steel being used.












F_v - denotes the shear stress (psi or ksi) applied to the bolt.

F_t - denotes the tensile axial stress (psi or ksi) applied to the bolt.

4. INTENDED USAGE

This paper is intended to give the engineer an understanding of structural bolting as specified by the AISC code. This paper is not intended to be a substitute for the AISC code, but rather a guide to locate specific requirements in the code.

PROPERTIES OF STEEL FASTENERS

| IDENTIFICATION GRADE MARK | SPECIFICATION | FASTENER DESCRIPTION | NOMINAL SIZE RANGE (IN) | MECHANICAL PROPERTIES | | |
|--|-------------------------|---|--|----------------------------|-----------------------------|-------------------------------|
| | | | | PROOF LOAD (psi) | YIELD STRENGTH MIN (psi) | TENSILE STRENGTH MIN (psi) |
|  NO GRADE MARK | ASTM A307 Grades A&B | BOLTS, SCREWS, STUDS | 1/4 THRU 4 | | | 60,000 |
|  | SAE J429 Grade 5 | BOLTS, SCREWS, STUDS | 1/4 THRU 1 OVER 1 THRU 1-1/2 | 85,000 74,000 | 92,000 81,000 | 120,000 105,000 |
| | ASTM A449 | | 1/4 THRU 1 OVER 1 THRU 1-1/2 OVER 1-1/2 THRU 3 | 85,000 74,000 55,000 | 92,000 81,000 58,000 | 120,000 105,000 90,000 |
|  | SAE J429 Grade 5.1 | SEMS | NO. 6 THRU 3/8 | 85,000 | | 120,000 |
|  | SAE J429 Grade 5.2 | BOLTS, SCREWS, STUDS | 1/4 THRU 1 | 85,000 | 92,000 | 120,000 |
|  | ASTM A325 Type 1 | HIGH STRENGTH STRUCTURAL BOLTS | 1/2 THRU 1 1-1/8 THRU 1-1/2 | 85,000 74,000 | 92,000 81,000 | 120,000 105,000 |
|  | ASTM A325 Type 2 | | 1/2 THRU 1 | 85,000 | 92,000 | 120,000 |
|  | ASTM A325 Type 3 | | 1/2 THRU 1 1-1/8 THRU 1-1/2 | 85,000 74,000 | 92,000 81,000 | 120,000 105,000 |
|  | SAE J429 Grade 7 | BOLTS, SCREWS | 1/4 THRU 1-1/2 | 105,000 | 115,000 | 133,000 |
|  | SAE J429 Grade 8 | BOLTS, SCREWS, STUDS | 1/4 THRU 1-1/2 | 120,000 | 130,000 | 150,000 |
| | ASTM A354 Grade BD | | | | | |
|  NO GRADE MARK | SAE J429 Grade 8.1 | STUDS | 1/4 THRU 1-1/2 | 120,000 | 130,000 | 150,000 |
|  | ASTM A490 | HIGH STRENGTH STRUCTURAL BOLTS | 1/2 THRU 1-1/2 | 120,000 | 130,000 | 150,000 MIN 170,000 MAX |